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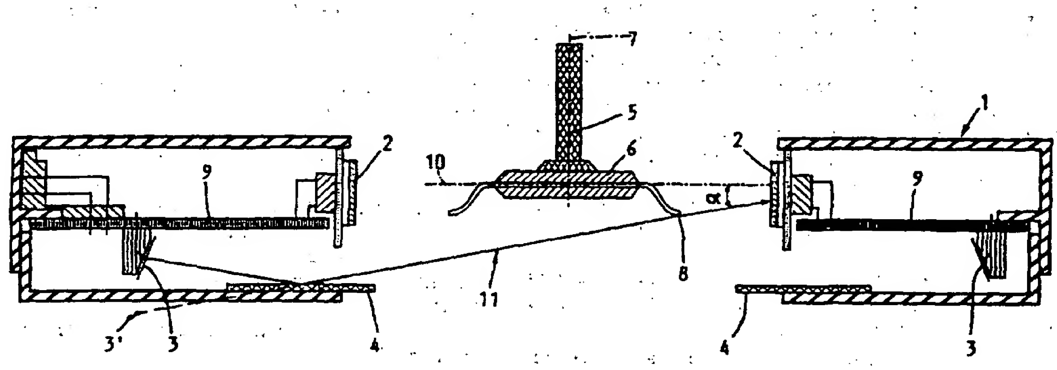
(54) Title: PROCESS FOR FORMING ON AN OPTO-ELECTRONIC TRANSDUCER A SHADOW IMAGE OF AT LEAST A PART OF AN ELECTRONIC COMPONENT



(57) Abstract

A process for forming a shadow image of a part of an electronic component (6) comprising the steps of: placing the electronic component (6) onto holding means (5), moving said holding means (5) together with said component (6) along an axis (7) so that at least said part is situated in a light beam (11) to the opto-electronic transducer (2), wherein said part is illuminated in such a manner that said light beam forms an angle α with a plane (10) through the body of said component, substantially parallel to the lead tips (8) of the component, comprised between 1 and 25 degrees.

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"Process for forming on an opto-electronic transducer a shadow image of at least a part of an electronic component."

The present invention relates to a process for forming on an opto-electronic transducer a shadow image of at least a part of a lead of an electronic component, said process comprising the steps of :
placing the electronic component onto holding means;
moving said holding means together with said component along an axis so that at least said part is situated in a light beam from a multiple point light source to the opto-electronic transducer;
illuminating said part of said lead by means of a light beam originating from at least a first point source of said multiple point light source to form said shadow image.

Such a process is known from PCT/DE93/00208. According to this known process, said light beam forms substantially a right angle with a plane through the body of said component, substantially parallel to the lead tips of the component.

A drawback of this known process is that for moving said holding means together with said component so that at least said part is situated in the light beam from the multiple point light source to the opto-

electronic transducer, a second movement is necessary, i.e. either the transducer is displaced, or said holding means are displaced. This second movement is also required since the device, provided for performing said process, is designed to measure components having a large range of dimensions. Another drawback is that, due to the distance between the light source and the transducer, relative large vertical dimensions of the device are required.

The object of the invention is to provide a process for forming on an opto-electronic transducer a shadow image of at least a part of a lead of an electronic component which does not present these drawbacks.

According to the invention, said part of said lead is illuminated in such a manner that said light beam forms an angle with a plane through the body of said component, substantially parallel to the lead tips of the component, comprised between 1 and 25 degrees.

By illuminating said part of said lead under such an angle, the component can be displaced in one single movement in order to be illuminated by said light beam. In the case of components having leads at opposite sides, the leads of one side will not disturb the shadow image of the leads of the opposite side, since the angle is larger than 0°. Moreover, this set-up allows to reduce the vertical dimensions of the device provided for performing said process.

The present invention relates further to a process for forming on an opto-electronic transducer a

shadow image of at least one location situated on a leadless electronic component, comprising the steps of : placing the electronic component onto holding means; moving said holding means together with said component along an axis so that at least said location is situated in a light beam from a multiple point light source to the opto-electronic transducer; illuminating said component by means of a light beam originating from at least a first point source of said multiple point light source to form said shadow image.

Such a process is characterised in that said location is illuminated in such a manner that said light beam forms an angle with a normal plane on said axis comprised between 1 and 25 degrees.

The present invention relates also to a process for determining coordinates of a point situated on a lead of an electronic component, said process comprising the steps of : placing the electronic component onto holding means; moving said holding means together with said component so that at least said point is situated in a light beam from a multiple point light source to an opto-electronic transducer; illuminating said point by means of a first light beam originating from a first point source of said multiple point light source, forming thereby a first shadow image of said point on said opto-electronic transducer, and defining a first line through said first point source and said first shadow image of said point; illuminating said point by means of a second light beam originating from a second point source of said multiple

point light source, forming thereby a second shadow image of said point on said opto-electronic transducer, and defining a second line through said second point source and said second shadow image of said point, whereby said second light beam is oriented according to a different direction than said first light beam so that said first line crosses said second line; determining the coordinates of said point by determining the crossing point of said first line and said second line.

Such a process is characterised in that said point is each time illuminated in such a manner that said light beams each form an angle with a plane through the body of said electronic component, substantially parallel to the lead tips of the component, comprised between 1 and 25 degrees.

The present invention relates finally to a process for determining the orientation of a leadless electronic component, placed onto holding means, which orientation is determined with respect to a reference plane through an axis along which the holding means are moved, comprising the steps of : moving said holding means together with said component along said axis so that at least a part of the outer surface of said component is situated in light beams from a series of n light sources to m opto-electronic transducers, whereby each opto-electronic transducer is associated with at least one of said n light sources.

Such a process is characterised by the further steps of : subsequently illuminating, for each

i^{th} light source ($1 \leq i \leq n$), an i^{th} line segment, situated on the surface of the electronic component and comprising said part, by means of an i^{th} light beam originating from said i^{th} light source thereby forming an i^{th} shadow image of said i^{th} line segment on the opto-electronic transducer associated with this i^{th} light source, whereby the light beams of said light sources each form an angle with a normal plane on said axis comprised between 1 and 25 degrees; determining, for each i^{th} light source ($1 \leq i \leq n$), an i^{th} projection angle φ_i formed by said i^{th} shadow image of said i^{th} line segment with respect to a predetermined line on said opto-electronic transducer, said predetermined line having an orientation value κ within said opto-electronic transducer, and determining the orientation angle γ_i formed by the projection of the i^{th} light beam onto said normal plane with respect to said reference plane, and forming an i^{th} couple (φ_i, γ_i); determining from said couples (φ_i, γ_i) the orientation of said component.

According to PCT/US92/01123, a process and a device for determining the orientation of a component are known. In this process, two movements are required : moving the component along the axis of the holding means and subsequently rotating the holding means with the component over small angles. According to the invention, only one movement is required. Moreover, it is not possible to determine the coordinates of a point

on a lead of an electronic component with leads by means of this device.

Preferably, said determination of said orientation is performed by : selecting from said couples (φ_i,γ_i) two pairs of couples, whereby each pair consists of a first couple having a projection angle γ with a value larger than the orientation value κ of said predetermined line and a second couple, originating from a light source in the neighbourhood of the light source generating said first couple, having a projection angle γ lower than the orientation value κ of said predetermined line; interpolating for each pair of couples to determine an orientation angle γ corresponding to a projection angle φ equal to said orientation value κ; determining the average value of the two determined orientation angles γ.

According to a first preferred embodiment of the process according to the invention, said illuminating is each time performed by a light source incident on a mirror plane. This allows to form said angle as large as possible and still keeping a small vertical dimension of the device.

According to a second preferred embodiment of the process according to the invention, at least one of said opto-electronic transducers is addressed in such a manner that only a part of the opto-electronic transducer is activated. This allows to read and transmit image data more quickly.

The invention will now be described referring to the annexed drawings.

Figure 1 is a sectional view of a device for performing the process according to the invention, wherein an electronic component with leads is placed on the holding means.

Figure 2 is a similar view as Figure 1, wherein a leadless electronic component is placed on the holding means.

Figure 3 a perspective view of a part of the device shown in Figure 1 or 2.

Figure 4 illustrates the triangulation principle.

Figure 5 is a schematic top view of a part of the main components of the device.

Figures 6 and 7 illustrate shadow images of a leadless electronic component by using the device according to the invention.

Figure 8 is a schematic perspective view of the projection of a line.

Figure 9 is a top view of Figure 8.

Figure 10 is a front view of Figure 8.

Figure 11 illustrates the angle of projection expressed in function of the orientation angle for different tilt angles.

Figure 12 illustrates results of measurements.

Figure 13 illustrates the orientation of the point sources and the dead zones.

Figure 14 to 17 are schematic top views illustrating the position determination.

The device according to the invention is used for forming at least one shadow image of an electronic component. It can be used for electronic components with leads as well as for leadless electronic components. For electronic components with leads, the device is provided for transporting an electronic component from a supply source, determining coordinates on the fly of at least one point situated on a lead of the component (usually the coordinates of all the lead tips are determined), and possibly mounting the electronic component on a printed circuit board. For leadless electronic components, the device according to the invention is provided for transporting the component from a supply source, determining the orientation of the component, and possibly adjusting the orientation before mounting it onto a printed circuit board.

As illustrated in Figures 1 to 3, the device according to the invention comprises a box 1 having a central cavity. On each of the four sides of the central cavity, an opto-electronic transducer 2 is mounted, for example a 2-D sensor having an active area of 50mm*4mm. The device comprises further multiple point light sources 3, each provided to illuminate a transducer 2 through the intermediary of a mirror plane 4. The multiple point light sources are for example rows of LED's, but can also be parallel light sources. For the sake of clarity, only one row of LED's has been

represented in Figure 3. It will be clear that one row of LED's can be provided on each of the four sides of the box. According to another embodiment, the device does not comprise mirror planes and the multiple point light sources are situated at the place indicated by 3'. This corresponds to the location of a row of virtual positions of the LED's, in case mirror planes are used, from which the light beams start. The advantage of the mirrors 4 is that a device is formed having a small vertical dimension.

The transducers 2 are preferably addressable in such a manner that only a limited area of the transducers are activated. Such transducers are sensors from the CMOS type. More details about such a type of sensors can be found in *"Pixel structure with logarithmic response for intelligent and flexible imager architectures", N. Ricquier and B. Dierickx, Microelectronic Engineering 19 (1992), p. 631-634* and in *"Random addressable CMOS image sensor for industrial applications", N. Ricquier and B. Dierickx, Sensor and Actuators A 44 (1994), p. 29-35.* This allows to limit the image acquisition to those areas of the sensor where the information can be expected, and therefore to decrease the time necessary to perform determination of coordinates and orientation, and in particular the readout time. Small components therefore can be inspected faster than larger components.

The transducers 2 and light sources 3 are connected to printed circuit boards (PCB's) 9. These PCB's comprise further control electronics for

controlling the transducers and the light sources and also analogue and digital electronics for the readout and transmission of the image data to an external processing board (not shown). The driving electronics and analogue and digital electronics are known as such in the state of the art and will therefore not be described further in detail.

A holding means 5 is provided, onto which an electronic component 6 can be placed. The holding means 5 is movable along its axis 7. The holding means is also slidably connected to said box 1. According to another embodiment, the box and the holding means form separate devices.

The multiple point lights sources 3 and the mirrors 4 are set up in such a manner that the light beams 11 from the mirror plane 4 to the transducer 2 illuminate at least a part of a lead 8 and form a vertical triangulation angle α with a plane 10 through the body of the electronic component 6, substantially parallel to the lead tips of the component, comprised between 1 and 25 degrees. If the electronic component is leadless as shown in Figure 2, then the multiple point light sources 3 and the mirrors 4 are set up in such a manner that the light beams 11 from the mirror plane 4 to the transducer 2 illuminate at least a location 13 of the electronic component, from which a shadow image has to be made, form a vertical triangulation angle α with a normal plane 14 on said axis 7 comprised between 1 and 25 degrees.

Determining the coordinates of a point situated on a lead of an electronic component, more particularly a lead tip of an electronic component, is performed by means of the triangulation principle. This principle is illustrated in Figure 4.

A lead tip 8 of an electronic component 6 is consecutively illuminated by a first and a second point source, said second point source illuminating said lead tip from a different direction than said first point source. Since the point sources are on fixed positions, the first and second point sources have coordinates which are exactly known, i.e. (x_1, y_1, z_1) and (x_2, y_2, z_2). Two shadow images of the lead tip are consecutively formed and the coordinates of the shadow images of the lead tip can be determined (x_{1p}, y_{1p}, z_{1p}) and (x_{2p}, y_{2p}, z_{2p}). A first line is defined through the first point source (x_1, y_1, z_1) and the first shadow image of the lead tip (x_{1p}, y_{1p}, z_{1p}). A second line is defined through the second point source (x_2, y_2, z_2) and the second shadow image of the lead tip (x_{2p}, y_{2p}, z_{2p}). The coordinates of the lead tip (a,b,c) are determined by determining the crossing point of said first line and said second line. To increase the accuracy, said lead tip could be illuminated from a third point source and a third line could be defined. When the coordinates of all the lead tips have been determined, a line is defined for each row of lead tips. In case of a quad flat pack (QFP), i.e. an electronic component having leads on its four sides, four lines are thus defined. From these lines, the orientation of the component can be deduced.

Under normal operating conditions, every lead is projected on the opto-electronic transducer in such a manner that the distance between the lead and the transducer is as short as possible, so that a relatively sharp shadow image of the lead is formed on the opto-electronic transducer. Figure 5 illustrates that more than two point sources per lead row can be required for the larger and small pitch components. Indeed, from a certain lateral angle χ, the tips of neighbouring leads start to overlap in projection. If leads 8′ and 8″ are illuminated by light beam 11′, having a lateral angle χ', a shadow image is formed of the to leads 8′ and 8″ on the transducer 2. If leads 8′ and 8″ are illuminated by light beam 11″, having a lateral angle χ'', the projection of the leads on the transducer 2 are overlapping. A set-up with a large vertical triangulation angle α does not show such a limit, but since it is desired that the device has a small vertical dimension this angle α has to be taken small, i.e. between 1 and 25 degrees. Preferably this angle is about 11 degrees. To inspect small pitch components (having for example a pitch of 300 μm and a lead width of 150 μm) taking into account that the component can be placed under a certain rotation angle δ, the light sources are placed at equal distances of 9 mm on each of the four rows of light sources.

As mentioned hereinabove, the device according to the invention can further be used for forming a shadow image of at least one location of a

leadless electronic component. An example of such a shadow image is illustrated in Figures 6 and 7, wherein a leadless electronic component having substantially a rectangular shape is illuminated from two different positions (light sources).

The shadow image of the leadless electronic component, more particularly of the bottom part of the leadless electronic component, is used for determining the orientation and the position of the component. Therefore, two algorithms are applied. To obtain more accurate results, it is necessary to use both algorithms in an iterative way because each separate algorithm contains the result of the other algorithm as a parameter. Since the rotation measurement is not very sensitive to the position, the convergence of the iterative process is guaranteed. Theoretical measurements have shown that the results are almost not influenced by a lateral displacement of the leadless electronic component. It has been found that upon displacement of 2 mm of the leadless electronic component, there was a variation on the angle determination of 2° and this with a leadless electronic component having a tilt angle of 10° (see later for the definition of the tilt angle). For smaller tilt angles, the variations are smaller. Knowledge of the orientation with an accuracy of 2° makes it possible to determine the position more accurately, which in turn causes the orientation error to become negligible (< 1/3°).

Figures 6 to 13 illustrate the determination of the orientation of a leadless electronic component having a substantially rectangular shape. As explained hereinabove (see Figure 2), the component, placed on said holding means 5, is moved in a first step along the axis 7 so that at least a location of the electronic component, from which a shadow image has to be made, is situated in the light beams 11 forming a vertical triangulation angle α with a normal plane 14 on the axis 7 comprised between 1 and 25 degrees. This concerns the light beams from all the light sources L1-L44, illustrated in Figure 13. In this case, said location corresponds to the bottom part of the component, and more particularly a line segment 15 corresponding to the bottom edge of the component that is situated at the back of the component (seen from a particular light source). This means that for each of the 44 light sources, a different line segment 15 will be found. The projection of this line segment is referred as 15p and is illustrated in Figures 6 and 7.

In a further step, a i^{th} line segment is subsequently illuminated, for each i^{th} light source ($1 \leq i \leq 44$) by means of a i^{th} light beam originating from said i^{th} light source, thereby forming a i^{th} shadow image of said i^{th} line segment on the opto-electronic transducer associated with this i^{th} light source. Examples of such shadow images are illustrated in Figures 6 and 7.

For each i^{th} shadow image, a i^{th} projection angle φ_i formed by the projection 15p of said line segment with respect to a predetermined line 16 on said opto-electronic transducer 2. This is illustrated in Figure 8, wherein said predetermined line 16 has an orientation value $\kappa = 0°$. In Figure 8, three different angles can be distinguished : the orientation angle γ of the line in the horizontal plane, the projection angle φ of the line on the transducer plane and the tilt angle β of the line perpendicular to the horizontal plane. The other two parameters, h and s, determine the vertical triangulation angle α, and correspond to the vertical, respectively horizontal distance between the line segment 15 and a point 17 corresponding to the position of the point source in case no mirrors are used and to the virtual position from which the light beam starts in case mirrors are used.

If the length of the line segment 15 is 2L, it can be deduced that the projection of this line on the x-axis has a length of $2L.\cos\gamma.\cos\beta$, on the y-axis $2L.\sin\beta$ and on the z-axis $2L.\sin\gamma.\cos\beta$.

According to Figure 9, it can be deduced that :

$$tg\rho_1 = \frac{\Delta s_1}{s+d} = \frac{L.\cos\gamma.\cos\beta}{s+L.\sin\gamma.\cos\beta}$$

$$tg\rho_2 = \frac{\Delta s_2}{s+d} = \frac{L.\cos\gamma.\cos\beta}{s-L.\sin\gamma.\cos\beta}$$

$$\Delta s = \Delta s_1 + \Delta s_2$$

so that

$$\Delta s = \frac{L.\cos\gamma.\cos\beta.(s+d).(s - L.\sin\gamma.\cos\beta + s + L.\sin\gamma.\cos\beta)}{s^2 - L^2.\sin^2\gamma.\cos^2\beta}$$

$$\Delta s = \frac{2Ls.\cos\gamma.\cos\beta.(s+d)}{s^2 - L^2.\sin^2\gamma.\cos^2\beta}$$

From Figure 10, it can be deduced that :

$$tg\varepsilon_1 = \frac{h_1}{d+s} = \frac{h - L.\sin\beta}{s + L.\sin\gamma.\cos\beta}$$

$$tg\varepsilon_2 = \frac{h_2}{d+s} = \frac{h + L.\sin\beta}{s - L.\sin\gamma.\cos\beta}$$

$$\Delta h = h_1 - h_2$$

so that

$$\Delta h = \frac{(d+s).[(h - L.\sin\beta).(s - L.\sin\gamma.\cos\beta) - (h + L.\sin\beta).(s + L.\sin\gamma.\cos\beta)}{s^2 - L^2.\sin^2\gamma.\cos^2\beta}$$

$$\Delta h = -\frac{(d+s)2.(hL.\sin\gamma.\cos\beta + ls.\sin\beta)}{s^2 - L^2.\sin^2\gamma.\cos^2\beta}$$

The relation between these parameters is then as follows :

$$tg\varphi = \frac{\Delta h}{\Delta s} = -\frac{hL.\sin\gamma.\cos\beta + Ls.\sin\beta}{Ls.\cos\gamma.\cos\beta}$$

$$tg\varphi = -\frac{h}{s}.tg\gamma - \frac{tg\beta}{\cos\gamma}$$

For this explanation, it is assumed that the light beam from the light source is in the plane formed by the y-axis and the z-axis, which is perpendicular to the transducer. The curve obtained by application of this formula is plotted in Figure 11, where φ is expressed in function of γ. This is done for different tilt angles β 0, 4, 8 12, 16 and 20°. The values for h and s are estimations of the distance between said point 17

and the line segment 15. These values can be corrected by application of position determination of the leadless component, which will be described further. From Figure 11 and from the formula of tgφ, it can be deduced that over the full 360° range, there are two intersection points where tgφ = κ, in this case 0°. Both points satisfy the following condition,

$\sin\gamma = -\frac{s}{h}.tg\beta$ or $\gamma = \arcsin\left[-\frac{s}{h}.tg\beta\right]$. Due to the nature of the arcsin, both points are symmetrically located around 90°. This means that by determining these two points, the 90° orientation of a component can be extracted by taking the average value of the two intersection points.

According to the invention, said orientation is thus performed by determining an orientation angle γ corresponding to a projection angle φ equal to said orientation value κ, in this case 0°. Figure 12 illustrates the results of measurements made with the device according to the invention, whereby the position of the point sources, illustrated in Figure 13, with respect to the x-axis are taken as orientation angle γ. From Figure 12, it appears clearly that some of the measurements do not contribute to the determination of the orientation. The orientation is determined by selecting two pairs of couples (φ_i, γ_i), each pair consists of a first couple having a projection angle γ larger than 0° and a second couple originating from a light source in the neighbourhood of the light source

generating said first couple and having a projection angle lower than 0°, interpolating for each pair of couples to determine orientation angles corresponding to a projection angle equal to 0° and determining the average values of the two orientation angles. This is a relatively accurate method since the tgφ-curve is almost linear in this area. The difference between this orientation angle; in this case 80° and 90° gives the orientation of the component, in this case -10°. In Figure 12, the orientation angles are found at the intersection with the X-axis (y=0). If κ is different from 0°, then the orientation angles are found at the intersection of an axis parallel to the X-axis (y=κ). In addition to the orientation angle, information is also obtained about the tilt angle β of the component.

Figure 13 illustrates the position of the point sources. It has to be noticed that dead zones 18 are present between the transducers. When the principal axis of the component, from which a shadow image has to be made, is oriented at about 45° and the projection angle measurement can not acquire measurement points in order to determine said couples, then a rotation of the component over about 45° can be requested.

For determining the position, use is made of an algorithm that calculates the centre point of leadless components using a width measurement on the projected shadow of the leadless component. While only the position in a horizontal plane has to be determined (no height measurement) the Figures 14 to 17

illustrating the algorithm are simply 2-D. At first sight, the projection of the centre point of an object can be approximated by the middle point of the projected shadow. However, two observations have to be made illustrated in Figures 14 and 15.

First of all, this procedure can only be used when it is the diagonal of the object (or any symmetrical line going through the centre point of the object) that is projected. When the component is oriented towards a point source in such a way that a single side of the object determines the total width measurement, then an error arises which is not negligible (see Figure 14, where the middle of the shadow is traced back to the point source and where the retraced line does not go through the centre point of the component).

Secondly, even when it is an object diagonal that determines the projection, the obtained middle point has to be corrected for the orientation of the component (more exactly the orientation of its diagonal). This is illustrated in Figure 15, where the line oq is parallel with the diagonal of the object and where the line pb is parallel with qc, dividing in this way both oq and oc in the middle. The middle point of the shadow is thus marked as b, while the real projection of the centre of the object is marked as a. With the orientation determined by means of the previous algorithm, it is possible to determine the projection line of the centre point more accurately. By repeating this algorithm for a number of projections

(from different sides and different point sources) and averaging the crossings of all the projection lines, the exact 2-D position of the component can be determined.

Depending on the dimensions of the leadless component to be inspected, the number of meaningful measurements that can be performed varies. This is due to the constraints imposed by the finite sensor dimensions and due to the need to project a diagonal. Figures 16 illustrates a component having dimensions (width and length) lower than the distance between the point sources, said component being illuminated from three neighbouring light sources L2, L1, L44 and providing three shadow images 19, 20 and 21, respectively. From these sources, at least two (L2 and L44) illuminate the diagonal of the object. These are the point sources providing the two largest dimensions of shadow images (19 and 21). Figure 17 illustrates a component having dimensions (width and length) higher than the distance between the point sources, said component being illuminated from three neighbouring light sources L2, L1, L44, and providing three shadow images 22, 23 and 24, respectively. From these sources, at least one (L44) illuminates the diagonal of the object. This is the point source providing the largest dimension of shadow images (24).

CLAIMS

1. A process for forming on an opto-electronic transducer (2) a shadow image of at least a part of a lead of an electronic component (6), said process comprising the steps of :

a) placing the electronic component (6) onto holding means (5),

b) moving said holding means (5) together with said component (6) along an axis (7) so that at least said part is situated in a light beam (11) from a multiple point light source to the opto-electronic transducer (2),

c) illuminating said part of said lead by means of a light beam (11) originating from at least a first point source (3) of said multiple point light source to form said shadow image,

characterised in that said part of said lead is illuminated in such a manner that said light beam forms an angle α with a plane (10) through the body of said component, substantially parallel to the lead tips (8) of the component, comprised between 1 and 25 degrees.

2. A process for forming on an opto-electronic transducer (2) a shadow image of at least one location situated on a leadless electronic component (12), comprising the steps of :

a) placing the electronic component (12) onto holding means (5),

b) moving said holding means (5) together with said component along an axis (7) so that at least said location is situated in a light beam (11) from a

multiple point light source to the opto-electronic transducer (2),

c) illuminating said component (12) by means of a light beam (11) originating from at least a first point source (3) of said multiple point light source to form said shadow image,

characterised in that said location is illuminated in such a manner that said light beam (11) forms an angle α with a normal plane (14) on said axis (7) comprised between 1 and 25 degrees.

3. A process for determining coordinates of a point situated on a lead of an electronic component, said process comprising the steps of :

a) placing the electronic component onto holding means,

b) moving said holding means together with said component so that at least said point is situated in a light beam from a multiple point light source to an opto-electronic transducer,

c) illuminating said point by means of a first light beam originating from a first point source of said multiple point light source, forming thereby a first shadow image of said point on said opto-electronic transducer, and defining a first line through said first point source and said first shadow image of said point,

d) illuminating said point by means of a second light beam originating from a second point source of said multiple point light source, forming thereby a second shadow image of said point on said opto-electronic transducer, and defining a second line through said

second point source and said second shadow image of said point, whereby said second light beam is oriented according to a different direction than said first light beam so that said first line crosses said second line,

e) determining the coordinates of said point by determining the crossing point of said first line and said second line,

characterised in that said point is each time illuminated in such a manner that said light beams each form an angle with a plane through the body of said electronic component, substantially parallel to the lead tips of the component, comprised between 1 and 25 degrees.

4. A process for determining the orientation of a leadless electronic component, placed onto holding means, which orientation is determined with respect to a reference plane through an axis along which the holding means are moved, comprising the steps of :

a) moving said holding means together with said component along said axis so that at least a part of the outer surface of said component is situated in light beams from a series of n light sources to m opto-electronic transducers, whereby each opto-electronic transducer is associated with at least one of said n light sources,

characterised by the further steps of :

b) subsequently illuminating, for each i^{th} light source ($1 \leq i \leq n$), an i^{th} line segment, situated on the surface of the electronic component and comprising said part,

by means of an i^{th} light beam originating from said i^{th} light source thereby forming an i^{th} shadow image of said i^{th} line segment on the opto-electronic transducer associated with this i^{th} light source, whereby the light beams of said light sources each form an angle with a normal plane on said axis comprised between 1 and 25 degrees,

c) determining, for each i^{th} light source ($1 \leq i \leq n$), an i^{th} projection angle φ_i formed by said i^{th} shadow image of said i^{th} line segment with respect to a predetermined line on said opto-electronic transducer, said predetermined line having an orientation value κ within said opto-electronic transducer, and determining the orientation angle γ_i formed by the projection of the i^{th} light beam onto said normal plane with respect to said reference plane, and forming an i^{th} couple (φ_i, γ_i),

d) determining from said couples (φ_i, γ_i) the orientation of said component.

5. Process according to claim 4, characterised in that said determination of said orientation is performed by :

a) selecting from said couples (φ_i, γ_i) two pairs of couples, whereby each pair consists of a first couple having a projection angle γ with a value larger than the orientation value κ of said predetermined line and a second couple, originating from a light source in the neighbourhood of the light source generating said first couple, having a projection angle γ lower

than the orientation value κ of said predetermined line,

b) interpolating for each pair of couples to determine an orientation angle γ corresponding to a projection angle φ equal to said orientation value κ,

c) determining the average value of the two determined orientation angles γ.

6. Process according to any one of the claims 1 to 5, characterised in that said illuminating is each time performed by a light source incident on a mirror plane.

7. Process according to any one of the claims 1 to 6, characterised in that at least one of said opto-electronic transducers is addressed in such a manner that only a part of the opto-electronic transducer is activated.

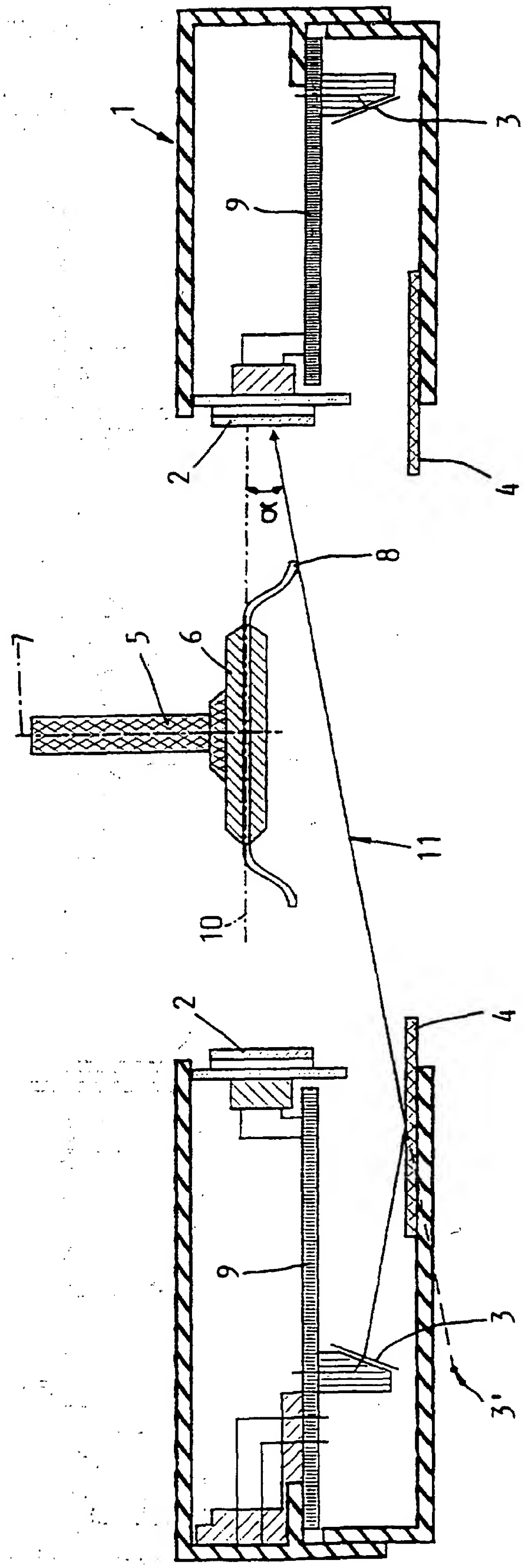


Fig.1

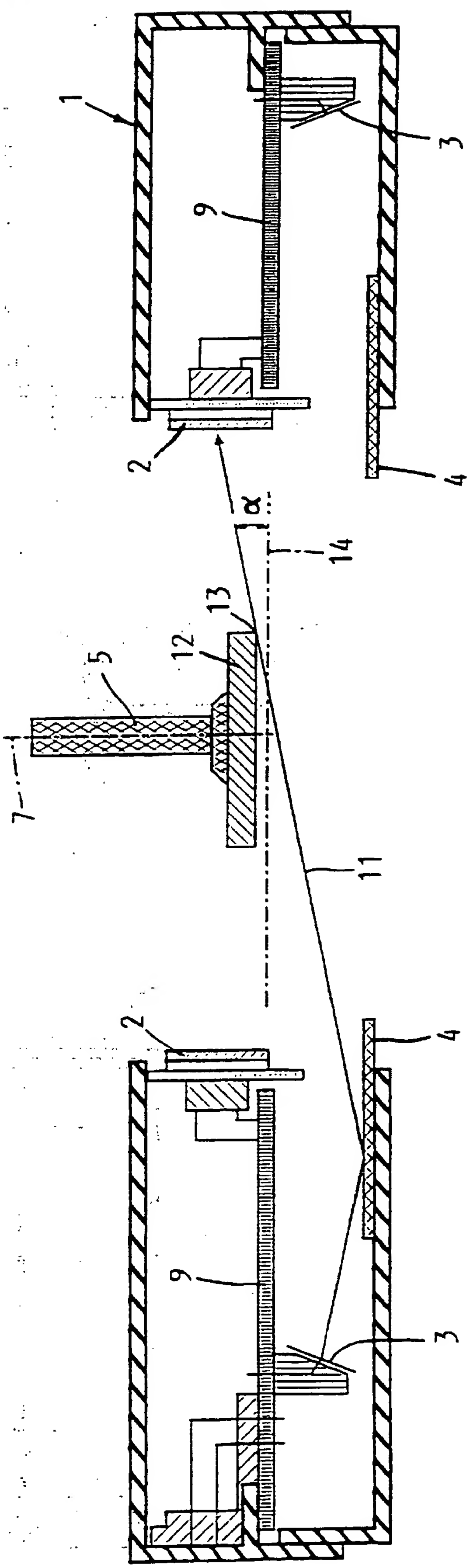


Fig.2

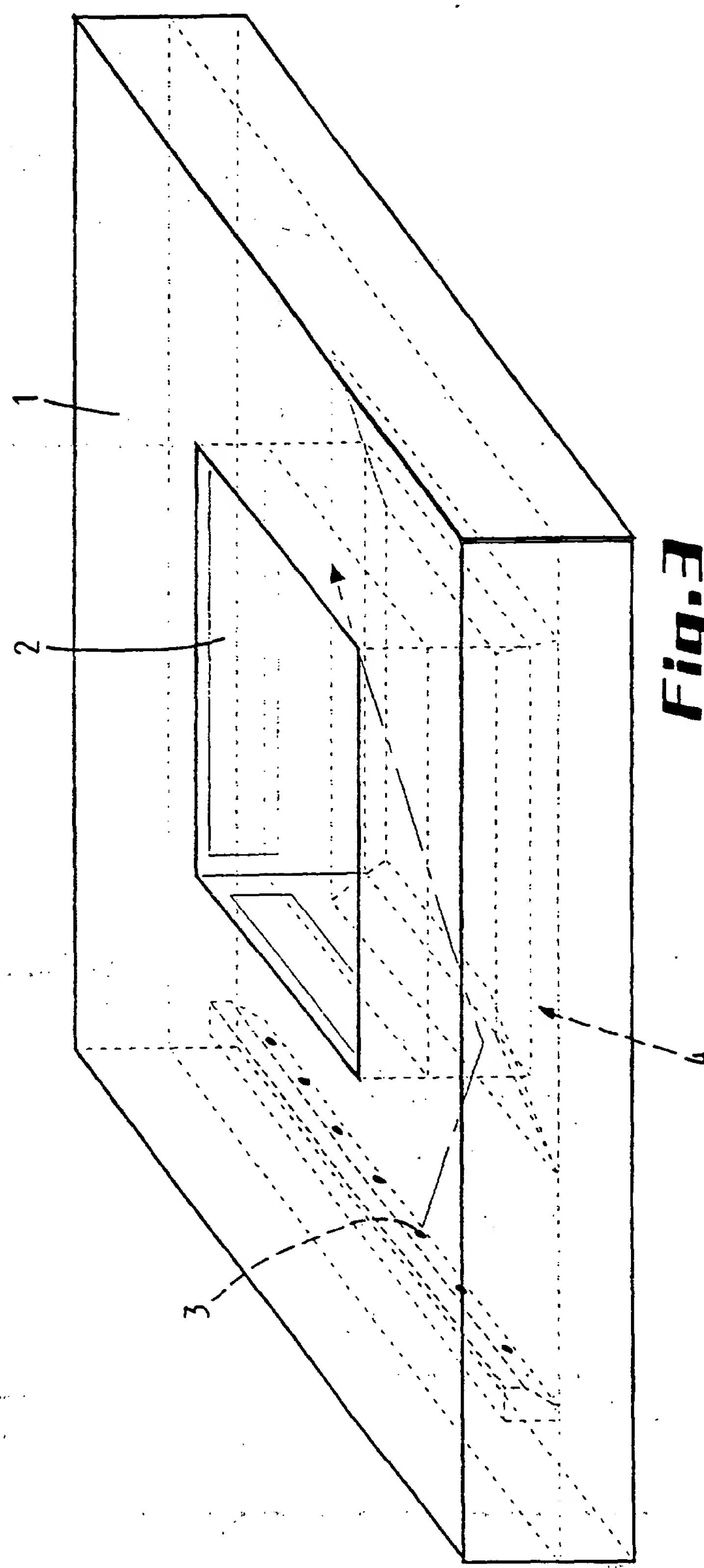


Fig.3

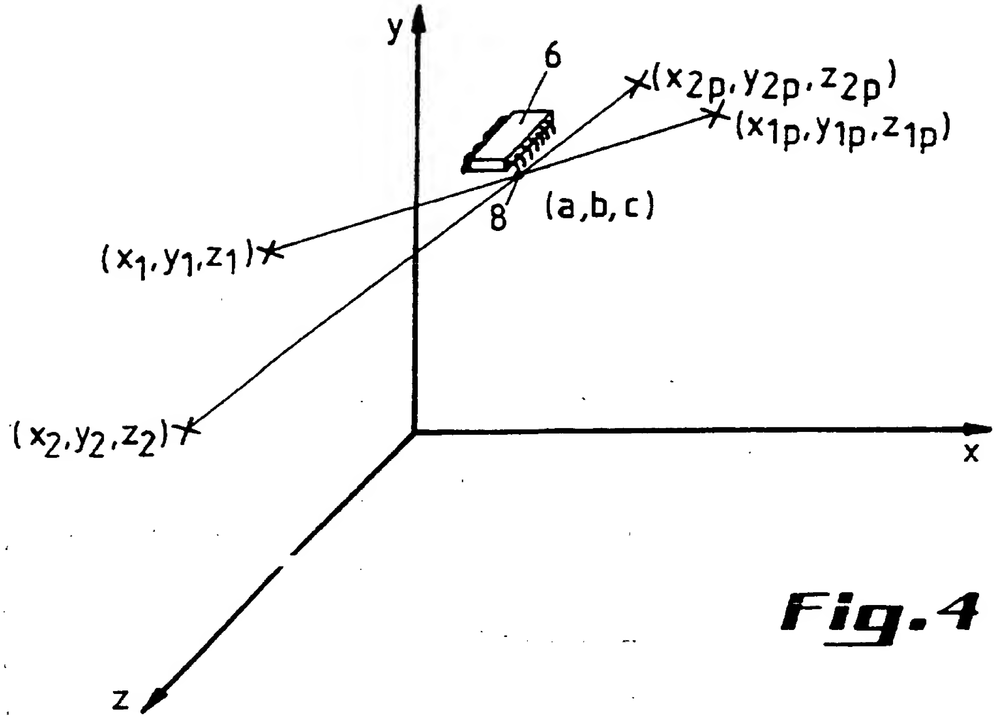


Fig.4

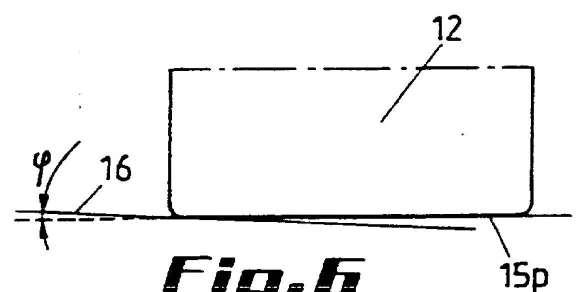


Fig.6

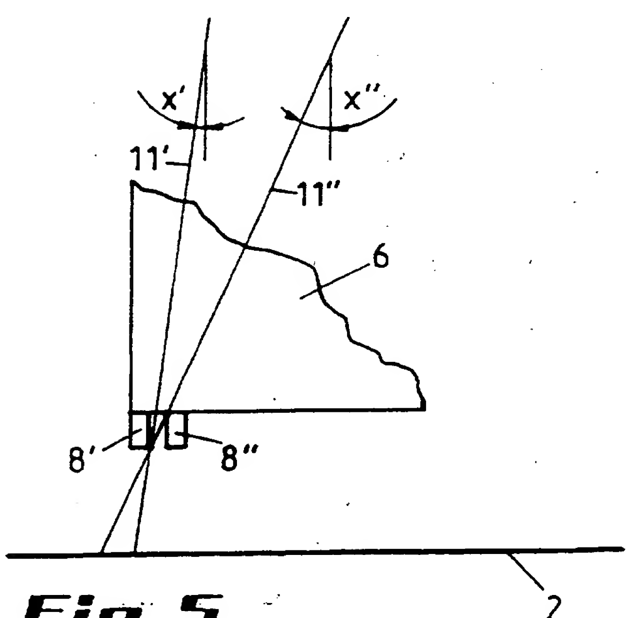


Fig.5

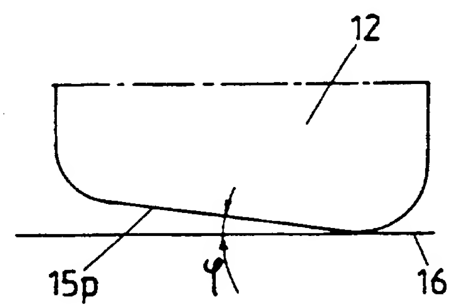


Fig.7

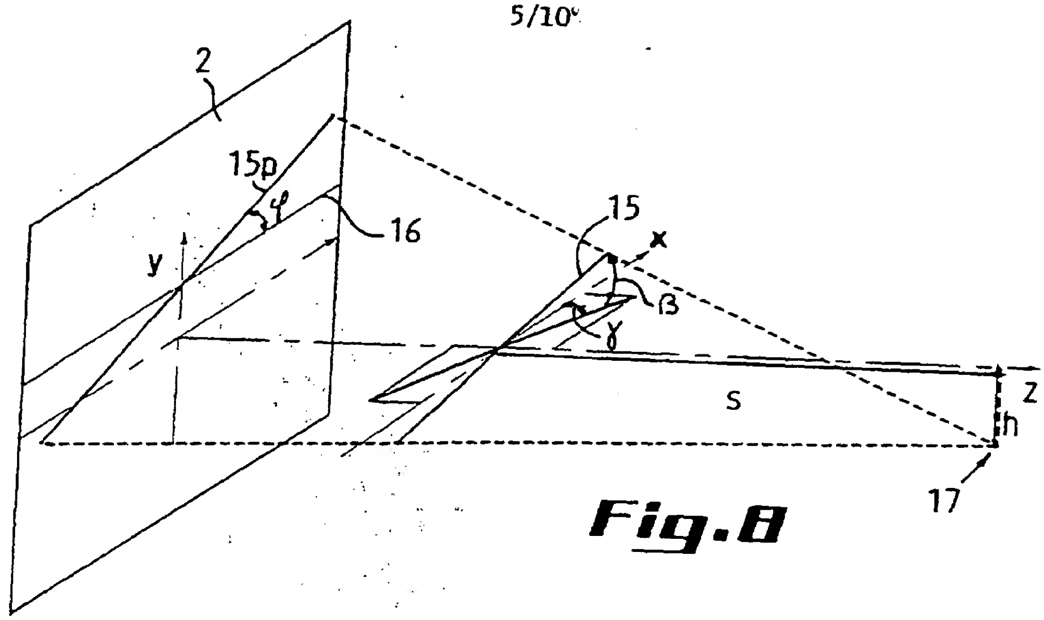


Fig.8

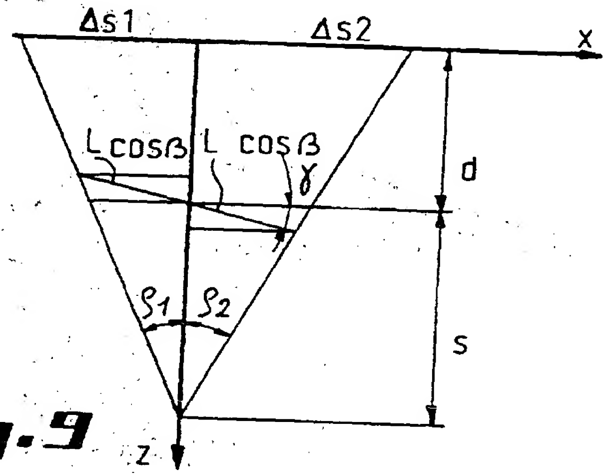


Fig.9

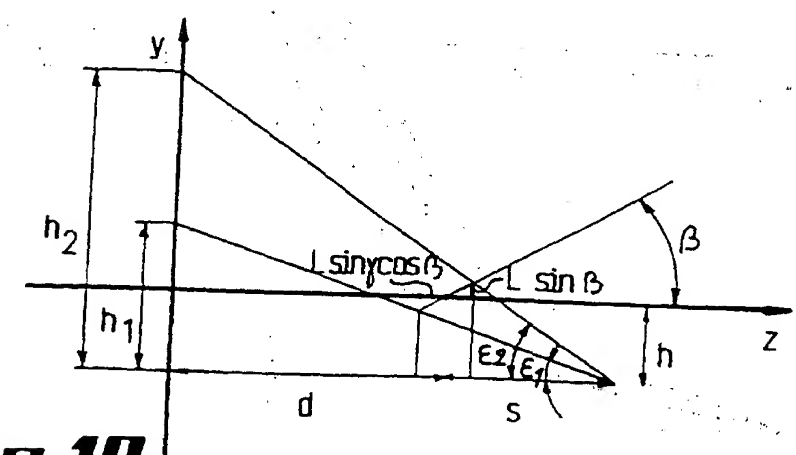


Fig.10

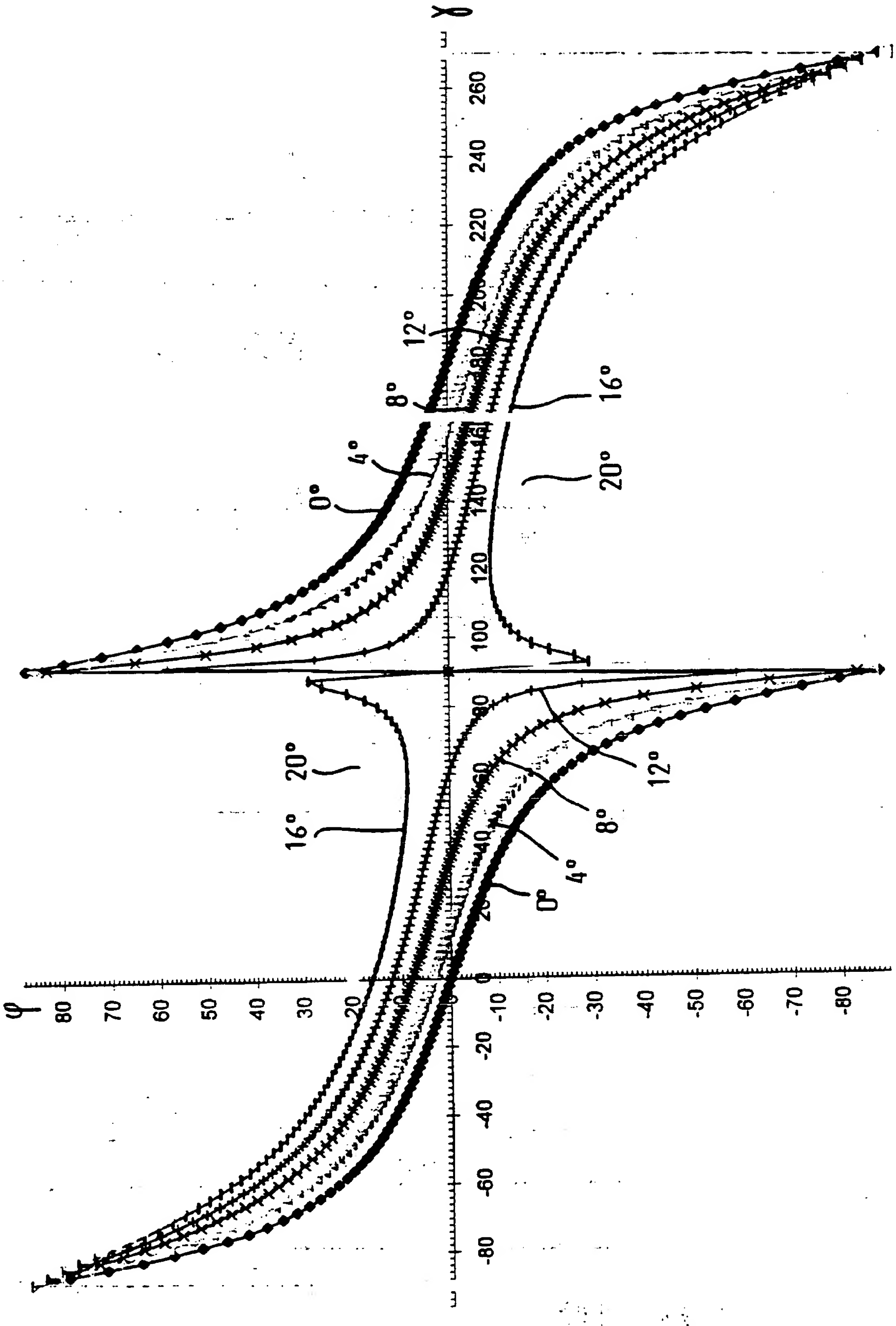


Fig.11

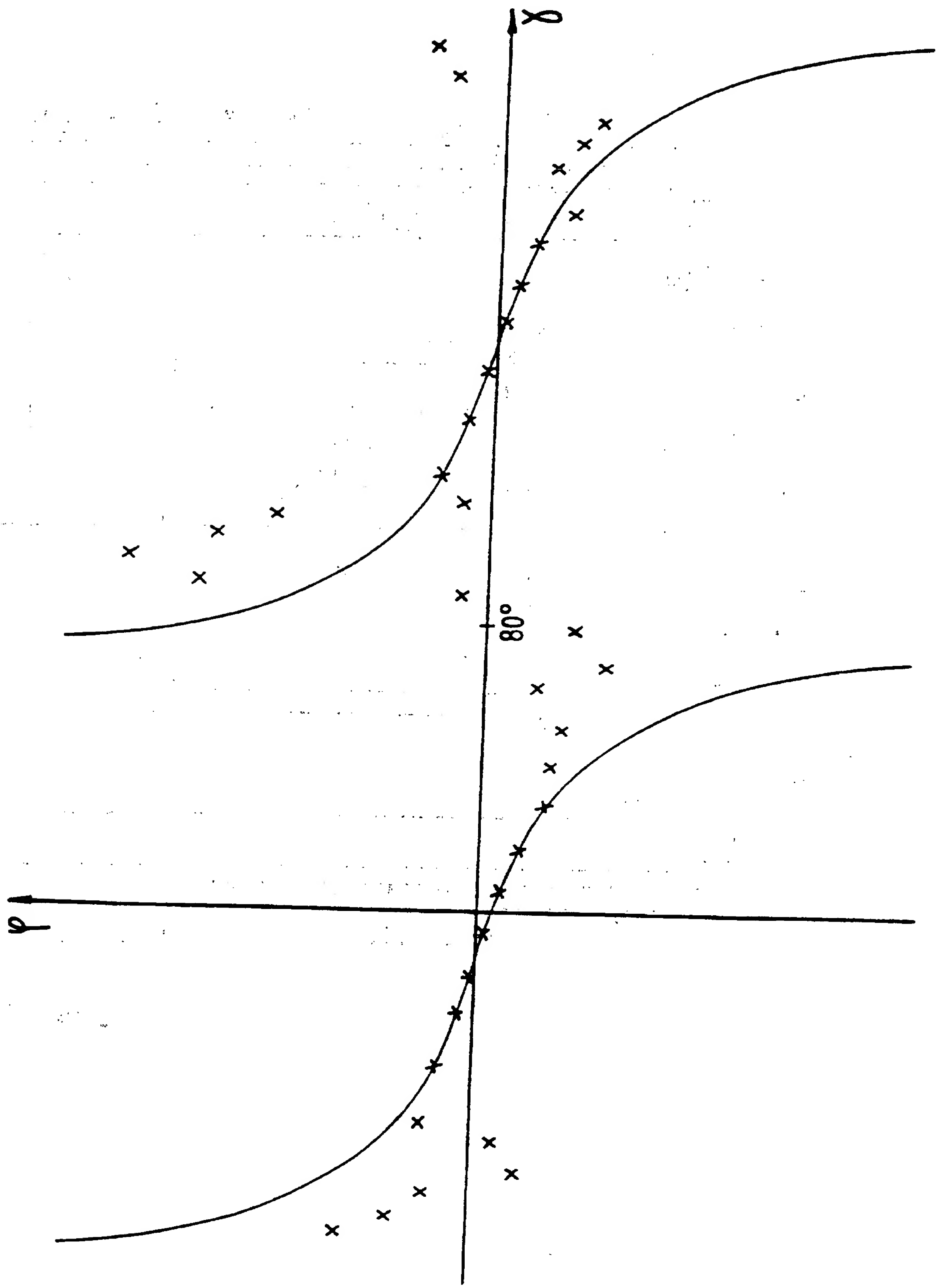
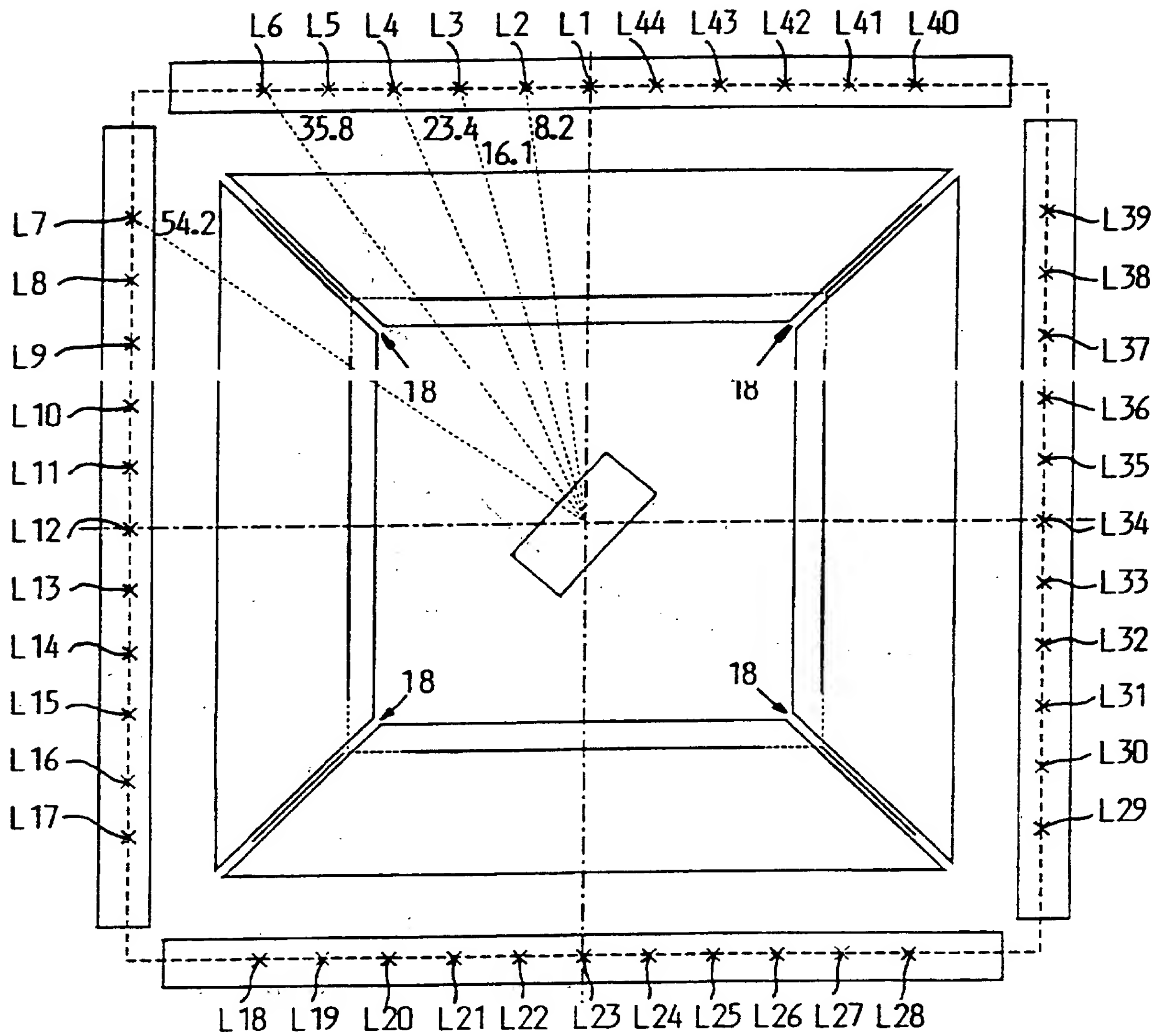


Fig.12


L6
L5
L4
L3
L2
L1
L44
L43
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L41
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54.2
L7
L8
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L28

Fig.13

9/10

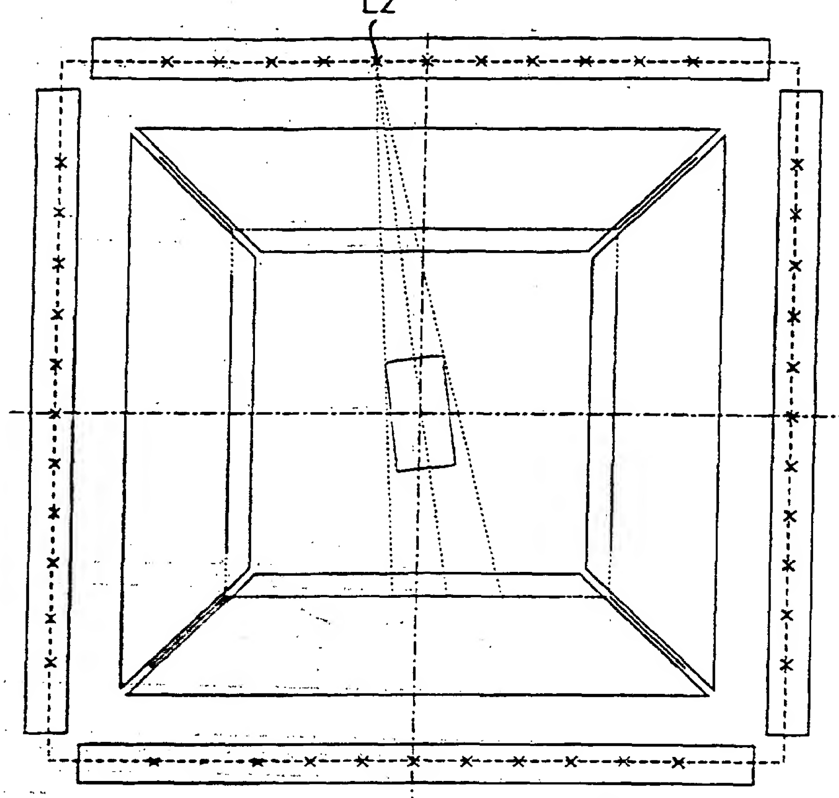


Fig.14

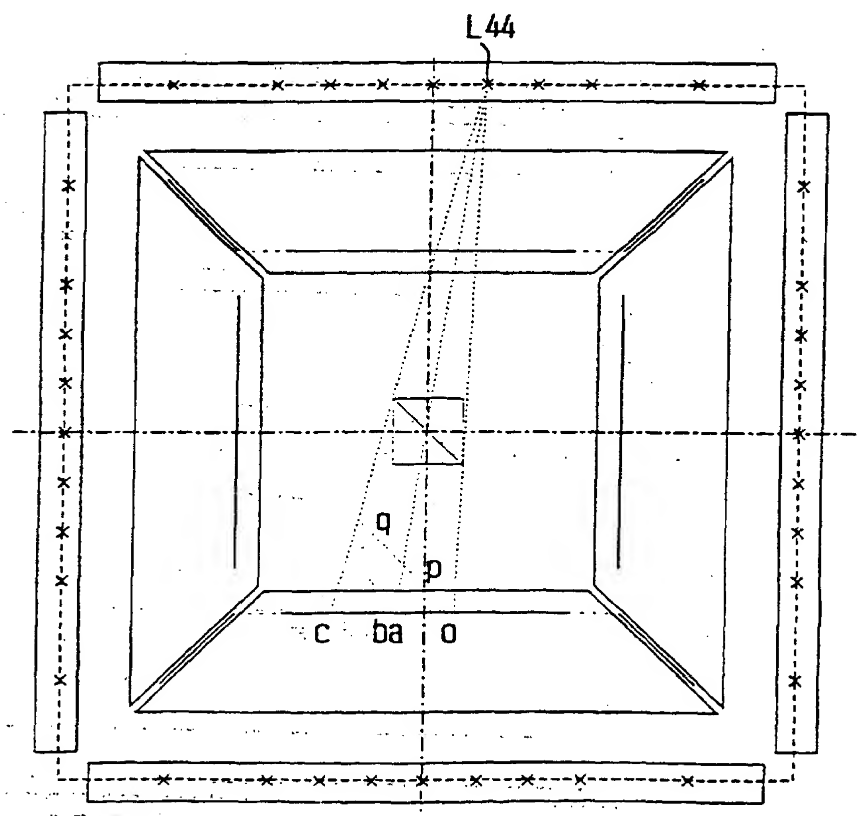
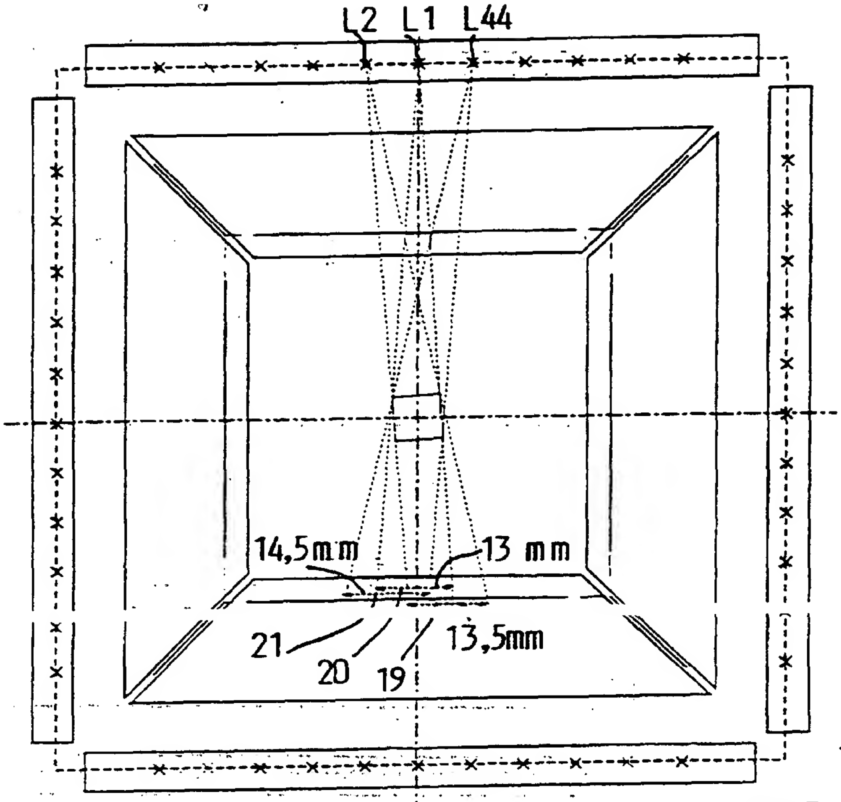


Fig.15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L44
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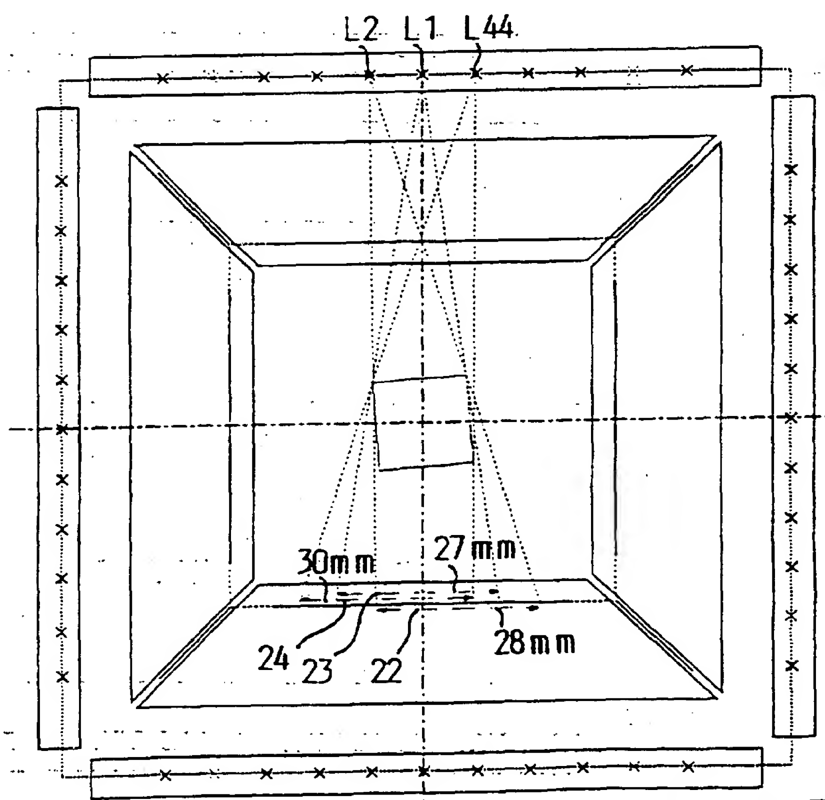
13 mm
21
20
19
13,5mm

Fig.16


L2
L1
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27mm
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28mm

Fig.17

INTERNATIONAL SEARCH REPORT

International Application No
PCT/BE 96/00013

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H05K13/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H05K G01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO,A,92 14988 (CYBEROPTICS CORP) 3 September 1992 cited in the application see the whole document ---	1,2
A	WO,A,93 19577 (SIEMENS AG) 30 September 1993 cited in the application see the whole document -----	1-4,7

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 October 1996	08. 11. 96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+ 31-70) 340-3016	Rieutort, A

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/BE 96/00013

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
WO-A-9214988	03-09-92	US-A-	5278634	11-01-94
		EP-A-	0572555	08-12-93
		JP-T-	6504847	02-06-94
WO-A-9319577	30-09-93	DE-A-	4209524	30-09-93
		EP-A-	0632952	11-01-95
		US-A-	5502890	02-04-96

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 02/00302

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H05K13/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H05K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 687 475 A (DOEMENS GUENTER) 18 November 1997 (1997-11-18) the whole document	1-7,9, 12,15-17
X	WO 97 30572 A (ICOS VISION SYSTEMS NV ;SMEYERS GUST (BE); RICQUIER NICO (BE)) 21 August 1997 (1997-08-21)	1-9,12, 13,15,17
A	the whole document	16

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 June 2002	27/06/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl	